Meeting the needs of gifted mathematics students

new VOICES

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presents an analysis of various approaches to catering for mathematical talent in the classroom.

Consider the following hypothetical classroom scenario:

Gina is a Year 3 student. It is the beginning of the school year and the teacher has realised that Gina demonstrates a keen awareness and understanding in mathematics. While the maths program seems to cater for the majority of the class it is clear that it is too easy for Gina and she is beginning to be disinterested. While the teacher demonstrates the steps for adding fractions Gina is doodling. She finds step-by-step processes as a waste of time when the solution can be found by just looking at the problem. Gina is more interested in the "hows" and "whys" of mathematical ideas than the computational "how-to" processes. She can see relationships among topics, concepts and ideas and due to her intuitive understanding of mathematical function and processes; she skips over steps to arrive at the correct answer.

The teacher asks her parents for further information about Gina's mathematical skills and is told that she has always had an early curiosity in mathematics and highly developed reasoning processes. The teacher organises for Gina to take an IQ test and she is found to have a specific academic aptitude in mathematics.

This case or scenario is one that is not uncommon in many of our primary or secondary classrooms. As educators it is crucial we cater and meet all learning needs of our students. This includes the needs of gifted and talented students. It is highly probable that

each year in our classrooms we will have students that are advanced in mathematics and this will pose as a challenge for us as teachers to meet their learning needs. In the case of Gina it is clear from observation and class assessment that the instruction in the regular classroom setting is not tailored to meet her unique needs. Johnson (2000) states that due to the sequential nature of mathematical content, pacing becomes a problem. If the situation does not change it is possible that gifted and talented students' interests in mathematics may be snuffed out and their talent may not be developed if they are not challenged. It is incorrect to conclude that they do not require special attention since it is easy for them to learn what they need to know. On the contrary, their needs dictate curriculum that is deeper, broader, and faster than what is delivered to other students.

This article seeks to examine studies conducted to find the best approach to cater for students advanced in mathematics and from these findings this article hopes to suggest possible solutions to meeting their learning needs.

What does research tell us?

The two most widely used educational modifications for gifted students are enrichment and acceleration. There has been much debate over the dilemma of choosing between acceleration to an advanced mathematics class placement and providing planned enrichment activities within the regular classroom setting.

Enrichment involves introducing new subjects to the curriculum, adding new topics in existing subject areas, or exploring topics currently in the curriculum in greater depth. Expanding the curriculum by adding tasks in thinking/problem solving skills or research skills is also a form of enrichment. Acceleration on the other hand involves arrangements due to students meeting existing curricular objectives at a faster than average rate or an earlier than average age.

The research findings for teaching approaches for gifted mathematic students have been organised into categories of postives, negatives and interesting to note, and are presented in Tables 1 to 4.

Table 1. Acceleration

	Postives	Negatives	Interesting to note
A. Grade skipping			
Vialle, Ashton, Carlon & Rankin (2001)	• Despite attitudes of resistant teachers and schools on accelerating students, findings show that students' emotional and psychological needs were unaffected and many stated that they were far happier. This suggests that academic needs and social/emotional needs are interlinked rather than the dichotomised view that teachers often take. • In each of the cases in Johnson (2001) each student stated their experience of acceleration through grade skipping was a positive one academically, socially and emotionally. • Parents facing resistant schools often are forced to become advocates for their children's needs therefore making them more involved in their children's life and education. They acquire knowledge about gifted programs and options and the rights for their children.	• Many teachers have a dichotomised view of gifted students needs and place more importance on their social/emotional than their academic needs despite research findings. • Much reluctance and at times antagonism regarding acceleration found in studies on the part of teachers and administrators. • After acceleration, satisfaction at school for gifted students depends largely on the quality of teachers and their willingness or ability to differentiate and provide appropriate curricula. • Cases where some students simply feel burdened down with volumes of work and tasks that are not necessarily challenging. • Acceleration is a temporary solution to addressing the needs of gifted students. The focus can remain as a placement decision rather than a program decision.	• NSW government has a policy that recommends that gifted students be accelerated at every stage of schooling as an option. • Research shows that successful acceleration cases have either dedicated parents or teachers with some formal study of gifted education as their advocates. • Educators who actively support acceleration are usually those who have received some training in gifted education whilst those who were most vocal in their opposition admitted to receiving no such training.

Table 1. Acceleration cont.

	Postives	Negatives	Interesting to note
A. Grade skipping cont.			
Swiatek, (2002); Howley & Howley (2002); Rotigel & Fello (2004)	• It is an inexpensive option to implement that requires little specialisation training for teachers, and can be used in most educational settings to meet the learning needs of many gifted students. • There is no evidence that acceleration harms willing students either academically or psychosocially. Instead it often helps them establish interests and build a strong foundation for future learning. • Research demonstrates that even though gifted students may be younger, those who are exceptionally talented in mathematics will learn material much more quickly and with fewer repetitions than the regular curriculum allows. • The spiral curriculum often means much mundane repetition for gifted students. However acceleration provides opportunities to work with advanced concepts, in-depth topic investigations, and problems with real-world applicability.	• The higher-grade teacher is the person the child will associate with most closely. If this teacher cannot at least tentatively endorse the proposed placement, other options would be more effective.	• For a grade skipping arrangement the child should be performing in the higher level curriculum as well as the children in the receiving group. However some research states that social and physical measurements can be substantially lower than the average of the receiving group. With support children adjust to their new surroundings.
Lewis (2002)	• Acceleration is appropriate in subjects that are linear-sequential, where there is a building up of previous knowledge and skills such as maths and science. • Acceleration may not be sufficient. Highly gifted students have complex profiles and are so varied. No single approach can be effective for all of them. (Not a one size fits all solution).	• Acceleration does not guarantee that students will receive quality teaching.	
Shore & Delcourt (1996); Sowell (1993)	• For teachers it requires no actual curriculum adaptation or differentiation. • Fast paced programs featuring diagnostic testing followed by prescriptive teaching enabled students to move through the mathematics curriculum quickly.	• The full burden of adaptation falls on the student. • Grade skipping is sometimes clumsy option primarily because the process is ad hoc and it does not differentiate the curriculum and it is not necessarily appropriate for all children.	
B. Vertical timetabling (subject acceleration)			
Vialle et al. (2001)	• Vertical timetabling allows accelerated progression in specific subject areas for students who are capable of achieving at the highest level of a curriculum stage in one or more subjects in advance of their peers. • Majority of students were positive about subject acceleration experience.	• After the initial 6 week honeymoon students become dissatisfied with the class pace.	• Interesting finding: within 6–10 weeks of subject acceleration, students were placed at the top of their accelerated class

Table 2. Enrichment and differentiation

	Postives	Negatives	Interesting to note
Kulik & Kulik (1992) Rotigel & Fello, (2004)	• Since gifted children often prefer to learn all they can about a particular mathematical idea before leaving it for new concepts, a more expansive approach to mathematics based upon student interest may avoid the frustration that occurs when the regular classroom schedule demands that it is time to move on to another topic. A more linear approach to mathematics is often better match for gifted children instead of the spiral curricula often found in textbook series and followed by classroom teachers. • Effective differentiation of instruction is very different from the unfortunate practice of assigning 20 problems to the gifted child while the remainder of the class is given only 10.	• The task of enriching & differentiating each lesson requires accessing additional resources, planning for small-group interaction, and perhaps even modifying lessons during delivery.	• Students' learning was directly related to the extent of differentiation they experienced.

Table 3. Ability grouping

	Postives	Negatives	Interesting to note
Shore & Delcourt (1996); Sowell (1993); Rotigel & Fello (2004); Johnson (2000)	• Over a school year, ability grouping can produce academic gains a month greater than for gifted students without this grouping even without curricular adjustment. • Situations in which students spend greater amounts of time together appear to be conducive to greater achievements with mutually rewarding exchanges and more positive attitudes in which time with like-minded peers is limited. • When grouped according to their understanding of mathematical concepts and ideas, teachers can cover concepts at an appropriate pace for the group. • If gifted students work independently, they are gaining no more than they could do at home. They need appropriate instruction, interaction with other gifted students, and regular feedback from the teacher.	• Gifted students when grouped according to ability within classes, they received less than 20% of the teacher's attention and no curricular differentiation in 84% of their learning activities (Westberg, Archambault, Dobyns & Salvin, 1993 cited in Shore & Delcourt, 1996).	• Despite the popularity of cooperative learning as a pedagogical tool, findings in gifted education state that it can limit instruction to grade level, and evaluation of success is primarily on basic skills. • Findings: gifted students in cooperative learning situations was unrelated to the achievement of other students. Also non-gifted students' social self-concept significantly decreased when interacting with gifted students.

Table 4. Technology

	Postives	Negatives
Sowell (1993); Rotigel & Fello (2004); Johnson (2000)	• Computers can assist mathematically gifted students in learning problem-solving skills. • Readily accessible classroom computers, supervised access to the Internet, and appropriate software programs offer opportunities for gifted students to advance at their own rate. • Technology can provide a tool, an inspiration, or an independent learning environment for any student. For gifted students it is often a means to reach the appropriate depth and breadth of curriculum and advanced product opportunities. For example: • Calculators can be used as an exploration tool to solve complex and interesting problems. Computer programming is a higher level skill that enhances problem solving abilities and promotes careful reasoning and creativity. Database, spreadsheet, graphic calculators can facilitate powerful data analysis. World Wide Web is a vast and exciting source of problems, contests, enrichment, teacher resources, and information about mathematical ideas that are not addressed in textbooks.	• Can be time consuming, needs supervision. • Resources are costly

Implications of the research overview

In Gina's case, some degree of acceleration is needed based on her ability. Simply learning in the highest Year 3 mathematics class will not meet her gifted need regardless of how well the teacher has differentiated the lesson. Gina has already acquired the content and concepts presented in these classes, so acceleration to a maths class at a higher grade (Year 5) may be the most viable option.

However, from research it is evident that a combination of approaches, are required to meet advanced students' needs. Acceleration is a temporary solution to addressing the needs of gifted students (Kulik & Kulik, 1992) and without a differentiated curriculum that challenges the student and a teacher who is knowledgeable about the needs of gifted students, acceleration will not satisfy the gifted student. Without enrichment and differentiation, acceleration can become an administrative option rather than a pedagogically sound program option.

The NSW DET acceleration support package (2004) also encourages the multiple program approach. Acceleration should not be implemented in isolation. Program options for the development of gifted and talented students should encompass a variety of methods including differentiated assignments, core curriculum, pull-out programs, in-class programs, and extracurricular activities such as after-school or Saturday programs, mentorship programs, summer programs, and competitions (Sheffield, 1994).

According to Lewis (2002), a successful program requires assessments (for diagnostic/prescriptive purposes), flexible scheduling and counselling. Flexible scheduling involves releasing students from studying material already mastered. Curriculum decisions should be based on the diagnostic/prescriptive information gathered in the initial assessment. This material forms the nucleus of the developmental aspect of the child's program. Counselling is a vital component of a gifted program. Time would have to be spent in individual sessions with the student's school counsellor/coordinator.

A student's subject acceleration must also be trialled for at least six weeks. Their progress needs to be monitored and additional curriculum and instruction modifications made where necessary.

Implications for the classroom teacher

Role of the teacher

Meeting the needs of each learner is the goal of every teacher. Being sensitive and aware of the unique characteristics of gifted students enable teachers to set more realistic expectations in the classroom (Rotigel & Fello, 2004). An enthusiasm for teaching and mathematics; confidence in their own abilities; strong content knowledge; and a flexibility and willingness to be co-learners with the students are all attitudes of a successful teacher (Sheffield, 1994). Teachers who see themselves as facilitators of learning, have a great deal to offer these students. He/she can help the student develop the skills necessary to learn, understand, and interpret an appropriately differentiated curriculum (Parke, 1992; Richert, 1993).

Focus on teaching strategies

According to Tomlinson (1995) in a differentiated class, teachers should use a variety of ways for students to explore curriculum content (content); a variety of sense-making activities or processes through which students can come to understand (process) and "own" information and ideas and a variety of options through which students can demonstrate or exhibit what they have learned (product).

Teaching strategies and areas of differentiation backed by research to develop an advanced mathematics student's talent include:

- modifying assessments
- curriculum materials — e.g., compacting, enrichment
- instructional techniques — e.g., open-ended questioning
- grouping models — e.g., ability grouping.
- use of technology.

Therefore the receiving teachers must adapt the content where appropriate, condense/ compact the concepts where applicable, alter the pace of the content acquisition, and allow for open-ended, multiple solutions to problems to address the student's need. Accessing all available resources using a variety of assessment tools, and allowing ability grouping are all aspects of helping develop the gifted mathematician's talent.

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